Spider

Spider, (order Araneida or Araneae), any of more than 46,700 species of arachnids that differ from insects in having eight legs rather than six and in having the body divided into two parts rather than three. The use of silk is highly developed among spiders. Spider behaviour and appearance are diverse, and the araneids outside Europe, Japan, and North America have not been thoroughly collected and studied.

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lynx spider

Lynx spider (*Peucetia viridans*).

Jack Dermid

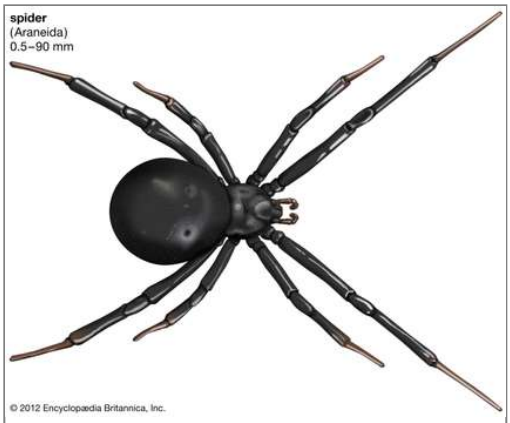
All spiders are predators, feeding almost entirely on other arthropods, especially insects. Some spiders are active hunters that chase and overpower their prey. These typically have a well-developed sense of touch or sight. Other spiders instead weave silk snares, or webs, to capture prey. Webs are instinctively constructed and effectively trap flying insects. Many spiders inject venom into their prey to kill it quickly, whereas others first use silk wrappings to immobilize their victims.

General features

Size range

Spiders range in body length from 0.5 to about 90 mm (0.02–3.5 inches). The largest spiders are the hairy mygalomorphs, commonly referred to as tarantulas, which are found in warm climates and are most abundant in the Americas. Some of the largest mygalomorphs include the goliath bird-eating spider (*Theraphosa leblondi* or *T. blondi*), found in parts of the Amazon, and the pinkfoot goliath (*T. apophysis*), limited to southern Venezuela. The smallest spiders belong to several families found in the tropics, and information about them first became known in the 1980s.

Female spiders generally are much larger than males, a phenomenon known in animals as sexual size dimorphism. Many female orb weavers, such as those in the families Tetragnathidae and Araneidae, show extreme size dimorphism, being at least twice the size of males of the same species. The extreme difference in body size appears to have arisen through selection processes favouring fecundity in females and “bridging” locomotion in males. Bridging is a technique used by spiders for orb web construction; the spider produces a silk thread that is carried by the wind and becomes attached to an object, forming a bridge. Small, light males can build and traverse silk bridges more rapidly than larger, heavier males can. Scientists suspect that this gives small males more mating opportunities, thereby favouring selection for their small size.



spider

A spider (order Araneida or Araneae).

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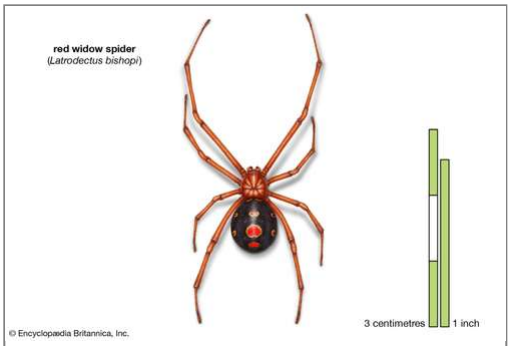
Distribution

Spiders are found on all continents (except Antarctica, although spider fragments have been reported there) and at elevations as high as 5,000 metres (16,400 feet) in the Himalayas. Many more species occur in the tropics than in temperate regions. Though most spiders are terrestrial, one Eurasian species is aquatic and lives in slow-moving fresh water. There are a few species that live along shores or on the surface of fresh or salt water.

Small spiders and the young of many larger species secrete long silk strands that catch the wind and can carry the spiders great distances. This behaviour, called ballooning, occurs in many families and expedites distribution. Some species are distributed in this way around the globe within the bounds of the northern jet stream. Ballooning spiders drift through the air at heights that range from 3 metres (10 feet) or less to more than 800 metres (2,600 feet).

Importance

All spiders are predators. Because of their abundance, they are the most important predators of insects. Spiders have been used to control insects in apple orchards in Israel and rice fields in China. Large numbers of spiders have also been observed feeding on insects in South American rice fields and in fields of various North American crops. Modern pest-management strategies emphasize the use of insecticides that do the least damage to natural predators of insect pests.



red widow spider

A red widow spider (*Latrodectus bishopi*).

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Although many spiders produce venom for use in capturing prey, few species are toxic to humans. The venom of the black widow (genus *Latrodectus*) acts as a painful nerve poison. The bite of the brown recluse and others of the genus *Loxosceles* may cause localized tissue death. Other venomous spiders include the tarantula-like funnel-web spider (genus *Atrax*) of southeastern Australia and some African members (baboon spiders) of the family Theraphosidae of Africa and South America. In North America *Cheiracanthium mildei*, a small, pale spider introduced from the Mediterranean, and the native *Cheiracanthium inclusum* may enter houses in late fall and are responsible for some bites. Occasionally tissue death at the site of the bite occurs. Some American tarantulas throw off abdominal hairs as a defense against predators. The hairs have tiny barbs that penetrate skin and mucous membranes and cause temporary itching and allergic reactions.

brown recluse spider

Brown recluse spider (*Loxosceles reclusa*) showing the characteristic violin-shaped marking on its cephalothorax.

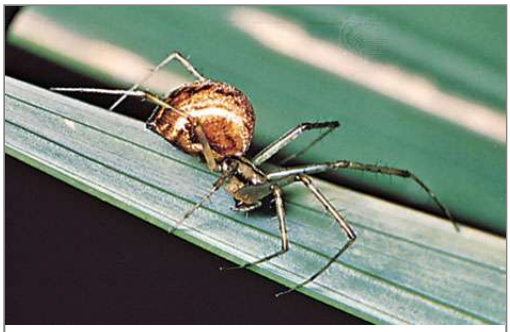
John H. Gerard/Encyclopædia Britannica, Inc.

Certain species of orb weavers (Araneidae), tarantulas (Theraphosidae), and huntsman spiders (Sparassidae) and members of family Nephilidae are suspected predators of bats, especially species of vesper bats (family Vespertilionidae) and sheath-tailed bats (family Emballonuridae). Birds have also been known to become trapped in spider webs, and in some instances spiders have been observed feeding on birds. These reports have led scientists to propose that flying vertebrates may be an important source of prey for certain species of spiders.

Form and function

External features

The bodies of spiders, like those of other arachnids, are divided into two parts, the cephalothorax (prosoma) and the abdomen (opisthosoma). The legs are attached to the cephalothorax, which contains the stomach and brain. The top of the cephalothorax is covered by a protective structure, the carapace, while the underside is covered by a structure called the sternum, which has an anterior projection, the labium. The abdomen contains the gut, heart, reproductive organs, and silk glands. Spiders (except the primitive suborder Mesothelae) differ from other arachnids in lacking external segmentation of the abdomen and in having the abdomen attached to the cephalothorax by a narrow stalk, the pedicel. The gut, nerve cord, blood vessels, and sometimes the respiratory tubules (tracheae) pass through the narrow pedicel, which allows the body movements necessary during web construction. Among arachnids other than spiders, the tailless whip scorpions (order Amblypygi) have a pedicel but lack spinnerets. Spiders, like other arthropods, have an outer skeleton (exoskeleton). Inside the cephalothorax is the endosternite, to which some jaw and leg muscles are attached.



sheet-web weaver spider

Sheet-web weaver (*Linyphia montana*).

John Markham/Bruce Coleman Inc.

Spiders have six pairs of appendages. The first pair, called the chelicerae, constitute the jaws. Each chelicera ends in a fang containing the opening of a poison gland. The chelicerae move forward and down in the tarantula-like spiders but sideways and together in the rest. The venom ducts pass through the chelicerae, which sometimes also contain the venom glands. The second pair of appendages, the pedipalps, are modified in the males of all adult spiders to carry sperm (*see below* Reproduction and life cycle). In females and immature males, the leglike pedipalps are used to handle food and also function as sense organs. The pedipalpal segment (coxa) attached to the cephalothorax usually is modified to form a structure (endite) that is used in feeding.

The pedipalps are followed by four pairs of walking legs. Each leg consists of eight segments: the coxa, attached to the cephalothorax; a small trochanter; a long, strong femur; a short patella; a long tibia; a metatarsus; a tarsus, which may be subdivided in some species; and a small pretarsus, which bears two claws in spiders that do not build webs and an additional claw between them in web-building ones. The young of two-clawed spiders often have three claws. The legs, covered by long hairlike bristles called setae, contain several types of sense organs and may have accessory claws. A few species use the first pair of legs as feelers. Spiders can amputate their own legs (autotomy); new but shorter legs may appear at the next molt.

Internal features

Nervous system and senses

The nervous system of spiders, unlike that of other arachnids, is completely concentrated in the cephalothorax. The masses of nervous tissue (ganglia) are fused with a ganglion found under the esophagus and below and behind the brain. The shape of the brain, or epipharyngeal ganglion, somewhat reflects the habits of the spider; i.e., in the web builders, which are sensitive to touch, the posterior part of the brain is larger than in spiders that hunt with vision.

The simple eyes of spiders, which number eight or less, consist of two groups, the main or direct eyes (called the anterior medians) and the secondary eyes, which include anterior laterals, posterior laterals, and posterior medians. Structures called rhabdoms, which receive light rays, face the lenses in the main eyes; in the other eyes the rhabdoms turn inward. Both the structure of the secondary eyes and eye arrangement are characteristic for each family.

Other sense organs are long fine hairs (trichobothria) on the legs, which are sensitive to air currents and vibrations. Slit sense organs in the form of minute slits or several parallel slits either are located near the leg joints or are scattered over the body. The slit is closed toward the outside by a thin membrane and on the other side by another membrane that may be penetrated by a nerve. Slit sense organs are sensitive to stresses on the cuticle; other sense organs act as vibration receptors or hearing organs. Internal receptors (proprioceptors) provide information about body movement and position. Olfactory (smell-related) organs are specialized hollow hairs found at the tips of pedipalps and legs. Olfaction is used mainly to sense pheromones.

spider: trichobothrium

The trichobothrium of a spider.

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Digestion and excretion

Food is digested outside the mouth (preorally). Some spiders chew their prey as they cover it with enzymes secreted by the digestive tract, whereas others bite the prey and pump digestive enzymes into it before sucking up the liquefied internal tissues.

The mouth leads into a narrow passage, the pharynx, which leads to a sucking stomach, which is part of the midgut. The midgut has a variable number (usually four pairs) of blind extensions, or ceca, that extend into the first segments of the legs (coxae). Additional ceca and a branched digestive gland are located at the front of the abdomen. At the end of the gut a cecum (stercoral pocket, or cloaca) connects with the hindgut before opening through the anus.

The excretory system includes large cells (nephrocytes) in the cephalothorax that concentrate nitrogen-containing wastes, a pigment-storing layer (hypodermis), coxal glands, tubular glands (Malpighian tubules) in the abdomen, and the ends of the abdominal gut ceca, which are filled with a white excretory pigment (guanine). The excreta include various nitrogen-containing compounds—e.g., guanine, adenine, hypoxanthine, and uric acid.

Respiration

The respiratory system, located in the abdomen, consists of book lungs and tracheae. In spiders the book lungs are paired respiratory organs composed of 10 to 80 hollow leaves that extend into a blood sinus separated by small hardened columns. The lungs open into chambers (atria), which open to the outside through one or several slits (spiracles). Tracheae are tubes that conduct air directly to various tissues. The two respiratory organs at the very front end of the abdomen usually are book lungs, and the rear two are tracheae. However, in some groups both pairs are book lungs (as in the tarantula-like spiders) or tracheae (as in some minute spiders). It is impossible to determine from surface structure whether a spider has book lungs, tracheae, or both, because the respiratory organs are covered on the exterior by hardened plates.

Circulation

The circulatory system is best developed in spiders with book lungs and is least developed in spiders with bundles of tracheae going to various parts of the body. In all spiders the abdomen contains a tube-shaped heart, which usually has a variable number of openings (ostia) along its sides and one artery to carry blood (hemolymph) forward and one to carry it backward when the heart contracts. The ostia close during contraction. The forward-flowing artery, which goes into the cephalothorax, is branched in spiders with book lungs. The blood eventually empties into spaces, flows into the book lung sinuses, and travels into a cavity (pericardial cavity) from which it enters the heart through ostia. The blood contains various kinds of blood cells and a respiratory pigment, hemocyanin. Changes in blood pressure function to extend the legs and to break the skin at molting time.

Reproductive system

The sex organs (gonads) of male and female spiders are in the abdomen. The eggs are fertilized, as they pass through the oviduct to the outside, with sperm stored in the seminal receptacles after mating. The fertilized egg (zygote) develops in the manner typical of arthropod eggs rich in yolk (*see* arthropod: Reproductive system and life cycle).

Specialized features

Venom

Venom glands are present in most spiders, but they are absent in the family Uloboridae. The glands are located either in the chelicerae or under the carapace. The venom ducts extend through the chelicerae and open near the tips of the fangs. Venom glands probably originated as accessory digestive glands whose secretions aided in the external digestion of prey. Although the secretions of some spiders may consist entirely of digestive enzymes, those of many species effectively subdue prey, and venoms of a few species are effective against predators, including vertebrates. The spitting spiders (*Scytodes*, family Scytodidae) secrete a sticky substance that glues potential prey to a surface. The high domed carapace of the spitting spiders is a modification to house the large venom glands.

Sydney funnel-web spider (*Atrax robustus*)

Sydney funnel-web spider (*Atrax robustus*).

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Characteristics of the venom of various spiders, especially the black widow (genus *Latrodectus*), have been determined. The various protein components of the venom affect specific organisms, different components affecting mammals and insects. Widows exhibit warning coloration as a red hourglass-shaped mark on the underside of the abdomen; some have a red stripe. Because the spider hangs upside down in its web, the hourglass mark is conspicuous. The venom contains a nerve toxin that causes severe pain in humans, especially in the abdominal region, though a bite is usually not fatal. There are widow spiders in most parts of the world except central Europe and northern Eurasia. Some areas have several species. Although all appear superficially similar, each species has its own habits.

Redback spider (*Latrodectus hasselti*)

Redback spider (*Latrodectus hasselti*).

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brown widow spider

Brown widow spider (*Latrodectus geometricus*).

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funnel-web spider

Funnel-web spider (*Atrax robustus*) striking.

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In southeastern Australia the funnel-web spider (genus *Atrax*, a tarantula-like spider) is dangerous to people. Tarantulas (family Theraphosidae) are venomous, though their venom is mild; in humans the pain associated with a tarantula bite often is described as similar to that of a bee sting.

The bite of the brown recluse (*Loxosceles reclusa*) results in a localized region of dead tissue (necrotic lesion) that heals slowly. The larger *Loxosceles laeta* of South America causes a more severe lesion. The bites of several other species belonging to different families may occasionally cause necrotic lesions—e.g., *Lycosa raptoria*, certain bolas spiders (*Mastophora*), *Phidippus formosus*, *P. sicarius*, the northern yellow sac spider (*Cheiracanthium mildei*), and other sac spiders (*Cheiracanthium*). Knowledge of the effects of spider bites on humans is limited because in some species the bite is not noticed at the time it occurs or because the spider is never identified.

Silk

Although silk is produced by some insects, centipedes, and millipedes and a similar substance is produced by mites, pseudoscorpions, and some crustaceans (ostracods and amphipods), only the spiders are true silk specialists. Spider silks that have been studied are proteins called fibroin, which has chemical characteristics similar to those of insect silk. The silk is produced by different types of glands in the abdomen. Ducts from the glands traverse structures called spinnerets, which open to the outside through spigots. Abdominal pressure forces the silk to flow outward, although the rate of flow is controlled by muscular valves in the ducts. Primitive spiders (suborder Mesothelae) have only two types of silk glands, but orb weavers have at least seven, each of which produces a different kind of silk; e.g., aciniform glands produce silk for wrapping prey, ampullate glands produce the draglines and frame threads, and cylindrical glands produce parts of the egg sac. Epigastric silk glands of male spiders produce silk that emerges through spigots in the abdomen between the book lung covers and provides a surface for the sperm to be deposited upon during sperm induction. Silk may have evolved from an excretory product.

golden garden spider

Golden garden spider (*Argiope aurantia*), an orb weaver.

John H. Gerard/Encyclopædia Britannica, Inc.

Threads of silk from the orb weaver *Nephila* have a high tensile strength and great elasticity. Silk probably changes to a solid in the spigot or as a result of tension forces. Strands usually are flat or cylindrical as they emerge and are of surprisingly uniform diameter. The glob of silk that binds or anchors strands emerges from the spigot as a liquid.

The movable spinnerets, which consist of telescoping projections, are modified appendages. Two pairs are from the 10th body segment and two pairs from the 11th. *Liphistius*, of the suborder Mesothelae, is the only spider with a full complement of four pairs of spinnerets in the adult. Most spiders have three pairs, the forward central pair having been either lost or reduced to a nonfunctional cone (colulus) or flat plate (cribellum), through which open thousands of minute spigots. Spiders with a cribellum also have a comb (calamistrum) on the metatarsus of the fourth leg. The black widow is one such comb-footed spider (family Theridiidae). The calamistrum combs the silk that flows from the cribellum, producing a characteristically woolly (cribellate) silk.

Natural history

Reproduction and life cycle

Courtship

In male spiders the second pair of appendages (pedipalps) are each modified to form a complex structure for both holding sperm and serving as the copulatory organs. When the time for mating approaches, the male constructs a special web called the sperm web. The silk for it comes from two sources, the spinnerets at the end of the abdomen and the spigots of the epigastric silk glands located between the book lungs. A drop of fluid containing

sperm is deposited onto the sperm web through an opening (gonopore) located on the underside of the abdomen. The male draws the sperm into his pedipalps in a process known as sperm induction. This may take anywhere from a few minutes to several hours. Sperm induction may occur before a male seeks a mate or after the mate has been located. If more than one mating occurs, the male must refill the pedipalps between copulations.

The way in which a male finds a female varies. Males generally wander more extensively than females. The wandering males of some species will often follow silk threads. Research has shown that some may recognize both the threads produced by a female of his own species and the female's condition (i.e., whether she is mature and receptive). Pheromones incorporated into the silk by the female are involved in this behaviour. Other species, especially jumping spiders (family Salticidae), use visual senses to recognize mates.

Males in a few species locate a female and unceremoniously run to her and mate. In most species, however, elaborate courtship patterns have evolved, probably to protect the male from being mistaken for prey. The male of the orb weaver family (Araneidae) and some others court by rhythmically plucking the threads of a web. After the female approaches, he pats and strokes her before mating. When male wolf spiders or jumping spiders see a female, they wave the pedipalps, conveying a visual message characteristic of the species. An appropriate response from a female encourages the approach of the male. Some male wolf spiders tap dry leaves, perhaps to attract a female. Aggregations of tapping males produce sound that can be heard some distance away. A male crab spider quickly and expertly wraps his intended mate with silk. Although the female is able to escape, she does not do so until mating has been completed. After the male of the European nursery-web spider has located a suitable mate, he captures a fly, wraps it in silk, and presents it to the female; while the female is occupied with eating the fly, the male mates with her. If no fly is available, the male may wrap a pebble. Some male spiders use their specialized jaws or legs to hold and immobilize the jaws of the female during mating.

Mating

In most groups, after a male has successfully approached a female and mounted her, he inserts his left pedipalp into the left opening of her genital structure and the right pedipalp into the right opening. In some primitive spiders (e.g., haplogynes, mygalomorphs) and a few others, the male inserts both pedipalps simultaneously into the female's genital slit.

The female genital structure, or epigynum, is a hardened plate on the underside of the abdomen in front of the gonopore. After the sperm are transferred into the epigynum, they move into receptacles (spermathecae) that connect to the oviducts. Eggs are fertilized as they pass through the oviducts and out through the gonopore.

The force that causes the injection of sperm from the pedipalp of the male into the receptacle of the female has not been established with certainty but may involve increased blood pressure expanding the soft vascular tissue (hematodocha) between the hard plates of pedipalps. This causes a bulbous structure containing a duct to twist and to hook into the epigynum of the female and inject the sperm as if they were being squeezed from a bulb syringe.

Mating may require only seconds in some species but hours in others. Some males recharge their pedipalps and mate again with the same female. After mating, the males of some species smear a secretion over the epigynum, called an epigynal plug, that prevents the female from mating a second time. Male spiders usually die soon after, or even during, the mating process. The female of one European orb weaver species bites into the abdomen of the male and holds on during mating. Although some females eat the male after mating, this practice is not common. The male of the black widow (genus *Latrodectus*), for example, usually dies days after mating, although occasionally he is so weak after mating that he is captured and eaten by the female. Male *Nephilengys malabarensis* spiders of Southeast Asia and the southwestern Pacific region are thought to escape sexual cannibalism through remote copulation, in which the male's copulatory organ detaches during mating and remains in the female, enabling prolonged sperm transfer. Females of some species mate only once, whereas others mate several times with the same male or mate with several different males. The long-lived females of mygalomorph spiders must mate repeatedly because they shed their skins once or twice a year, including the lining of the spermathecae.

Eggs and egg sacs

Female spiders produce either one egg sac containing several to a thousand eggs or several egg sacs each with successively fewer eggs. Females of many species die after producing the last egg sac. Others provide care for the young for some period of time; these females live one or, at most, two years. Females of the mygalomorph spiders may live up to 25 years and those of the primitive haplogyne spiders up to 10 years.

The protective egg sac surrounding the eggs of most spiders is made of silk. Although a few spiders tie their eggs together with several strands of silk, most construct elaborate sacs of numerous layers of thick silk. Eggs, which often have the appearance of a drop of fluid, are deposited on a silk pad and then wrapped and covered so that the finished egg sac is spherical or disk-shaped. The females of many species place the egg sac on a stalk, attach it to a stone, or cover it with smooth silk before abandoning it. Other females guard their egg sacs or carry them either in their jaws or attached to the spinnerets. The European cobweb spider (*Achaearanea saxatile*) constructs a silken thimble-shaped structure and will move the egg sac into or out of this structure to regulate egg temperature. Female wolf spiders carry their egg sacs attached to the spinnerets and instinctively bite the egg sac to permit the young to emerge after a certain length of time has elapsed. If a female loses an egg sac, she will make searching movements and may pick up a pebble or a piece of paper and attach it to the spinnerets.

Maturation

The young of most species are independent when they emerge from the egg sac. After hatching, wolf spiderlings, usually numbering 20 to 100, climb onto the back of their mother and remain there about 10 days before dispersing. If they fall off, they climb back up again, seeking contact with bristlelike structures (setae). Some female spiders feed their young. When food has been sufficiently liquefied by the female (in spiders, digestion occurs outside the mouth), the young also feed on their mother's prey. The female of some spiders, including one European species (*Coelotes terrestris*), dies at the time the young are ready to feed, and they eat her carcass. The

mother of one web spider (*Achaearanea riparia*) plucks threads of the web to call her young, both to guide them to food sources and to warn them of danger.

Young spiderlings, except for size and undeveloped reproductive organs, resemble adults. They shed their skins (molt) as they increase in size. The number of molts varies among species, within a species, and even among related young of the same sex. Males generally mature earlier and have fewer molts (2 to 8) than females have (6 to 12). Males of some species are mature when they emerge from the egg sac, one or two molts having occurred before emergence. Some spiders mature a few weeks after hatching, but many overwinter in an immature stage. Mygalomorph spiders require three to four years (some authorities claim nine years) to become sexually mature in warm climates.

Before molting, many spiderlings hang by the claws in some inconspicuous place, although mygalomorph spiders turn on their side or back. The protective covering (carapace) of the cephalothorax breaks, either below the eyes or at the posterior end, because of increased blood pressure. The spider then laboriously extracts its legs and abdomen from the old cuticle (skin). Emergence is accompanied by wide fluctuations of blood pressure. These pressure changes raise and lower the setae and gradually force the legs free. The cast-off cuticle, or exuviae, remains behind. Many web builders molt while suspended, with the newly emerged spider dangling from a strand of silk. Until the new exoskeleton hardens, the spider is helpless; thus, molting is hazardous for spiderlings. They may dry out before successfully emerging from the old cuticle, or they may fall victim to a predator while defenseless. Even a small injury during the molting period is usually fatal. Growth and molting are believed to be under the control of hormones. On occasion some spiderlings fail to molt, whereas others undergo delayed molts, perhaps because of faulty hormone balance, and may die. Many spiderlings eventually disperse by ballooning, usually in the fall.

Feeding behaviour

Stalking prey

Most hunting spiders locate prey by searching randomly or by responding to vibrations. Wolf spiders and jumping spiders have keen eyesight. The latter stalk their prey to within 5 to 10 cm (2 to 4 inches) and then pounce when it moves. Many crab spiders wait for prey on flowers of a colour similar to their own. They use their legs to grasp an unsuspecting insect and then give it a lethal bite.

crab spider

Crab spider (*Misumenoides aleatorius*) awaiting prey in the flower of a thistle.

John H. Gerard

Unique among the hunters are the spitting spiders (family Scytodidae). When these spiders encounter prey, they touch it, back off, and shoot a zigzag stream of sticky material over it. The sticky material, produced by modified venom glands in the cephalothorax, emerges from pores near the tips of the fangs located on the chelicerae. As the victim struggles, the spider approaches cautiously and bites the entangled insect.

Spider webs

Spiders that use silk to capture prey utilize various techniques. Ground-dwelling trap-door spiders construct silk-lined tubes, sometimes with silk trapdoors, from which they dart out to capture passing insects. Other tube-dwelling spiders place silk trip threads around the mouth of the tube. When an insect touches these threads, vibrations inform the spider of a victim's presence. Funnel-weaving spiders live in silk tubes with a narrow end that extends into vegetation or a crevice and an expanded sheetlike end that vibrates when an insect walks across it. Many web spiders construct silk sheets in vegetation, sometimes one above the other, and often add anchor threads, which trip unsuspecting insects. The irregular three-dimensional web of cobweb spiders (family Theridiidae) has anchoring threads of sticky silk. An insect caught in the web or touching an anchor line becomes entangled, increasingly so if it struggles. If a thread breaks, the elasticity of it pulls the insect toward the centre of the web.

trap-door spider

Trap-door spider (*Bothriocyrtum californicum*) standing at the entrance to its burrow. These spiders spin fitted hinged doors for their silk-lined nests.

Ruth Cordner—Root Resources/Encyclopædia Britannica, Inc.

The most elaborate webs are those of the orb weavers, whose circular nets are conspicuous on dewy mornings. This type of web is constructed by several spider families, which suggests that it is an efficient trap that enables the largest area to be covered with the least possible silk. The web acts like an air filter, trapping weak-flying insects that cannot see the fine silk. Most orb webs are rebuilt every day. The web may be up only during the day or only at night. If a web is damaged during capture of prey, the spider will repair that area. The ways by which spiders keep from becoming entangled in their own webs are not completely understood, nor is their mechanism for cutting the extremely elastic silk threads that are used in web construction.

To begin orb-web construction, the spider releases a silk thread that is carried by wind. If the free end does not become attached to an object, the spider may pull it back and feed on it. If it becomes firmly attached—for example, to a twig—the spider secures the thread and crosses the newly formed bridge, reinforcing it with additional threads. The spider then descends from the centre of the bridge, securing a thread on the ground or on a twig. The centre, or hub, of the web is established when the spider returns to the bridge with a thread and carries it partway across the bridge before securing it; this thread is the first radius, or spoke. After all the spokes are in place, the spider returns to the hub and constructs a few temporary spirals of dry silk toward the outside of the web. The spider then reverses direction, deposits ensnaring silk, and removes the initial spiral. The ensnaring threads form a dense spiral. It takes only about an hour to weave the radii and orb.

Some species attach a signal thread from the hub to a retreat in a leaf so that they are informed (by vibrations) of trapped insects; others remain head-down in the centre of the orb, locating prey by sensing tensions or vibrations in individual spokes. Webs of two spider families (Araneidae and Tetragnathidae) have spirals constructed of a sticky material that dries out after several days and must be rebuilt.

Spiders of the family Uloboridae build a web of woolly (cribellate) ensnaring silk. One group within this family (genus *Hyptiotes*) weaves only a partial orb. The spider, attached by a thread to vegetation, holds one thread from the tip of the hub until an insect brushes the web. The spider then alternately relaxes and tightens the thread, and the struggling victim becomes completely entangled. Tiny theridiosomatid spiders also control web tension.

Ogre-faced spiders (family Deinopidae) build small flat webs during the evening hours and then cut the attachments and spread the web among their four long front legs. During the night the web is thrown over a passing insect. The spider abandons or eats the web in the morning and passes the day resting on a branch before constructing a new web.

Bolas spiders (*Mastophora*, *Ordgarius*) release a single thread with a sticky droplet at the end and hold it with one leg. Some species swing this “bola,” and others throw it when a moth approaches. Male moths are attracted to this spider by its odour, which mimics that of female moths. Many other examples of web specializations have been described.

Spiders usually wrap a captured insect in silk while turning it, as on a spit, before biting it and carrying it either to a retreat or to the hub of the web for feeding or storage. Although the detachable scales of butterfly and moth wings facilitate their escape from the web, spiders have evolved a counterstrategy: they bite before wrapping them rather than afterward.

Some tropical species of spiders are social and live in large communal webs containing hundreds of individuals, most of them female. They cooperate to build and repair the web. The pack of spiders subdues, kills, and consumes insects that have been caught in the communal web.

Classification

Distinguishing taxonomic features

The Araneida are separated into three suborders: Mesothelae (segmented spiders), Orthognatha (mygalomorph spiders), and Labidognatha (araneomorph spiders). The segmented spiders are easily distinguished by indentations on the top of the abdomen—evidence of spiders’ common ancestry with scorpions. The other two suborders are differentiated on the basis of the type of movement of the two jaws; i.e., movement forward and down is orthognath (paraxial), and movement sideways and together is labidognath (diaxial). Other external features that distinguish suborders include the structure of the male pedipalps and the presence or absence of an epigynum in the female. Internal differentiating features include the presence and number of book lungs, number of small openings (ostia) in the heart, and extent of fusion of nerve ganglia in the prosoma. Families are distinguished on the basis of such characteristics as number and spacing of simple eyes, number of tarsal claws, number of spinnerets, habits, structure of chelicerae, and specialized (apomorph) characters such as glands, setae, and teeth and peculiarities of the external genitalia. Species and also genera of araneomorph spiders are usually separated by specializations of the female epigynum and male pedipalp.

Annotated classification

Numerous classification schemes were published in the 1930s, most of them in response to one by Alexander Petrunkevitch, but none of these is now acceptable and up-to-date. All classifications have relied heavily on the work of Eugène Simon, who published in France in the late 19th century. Newer tools, such as scanning electron microscopy, molecular methods, and cladistics, remain little-tried for spiders, but they have changed traditional classification schemes. In addition, many new spiders have been found in the Southern Hemisphere that do not readily fit into established families, a situation that prompts the proposal of new ones, though without an overall view for a new system. Fewer than 30 percent of the large neotropical spiders are known (and probably fewer of the small neotropical spiders), while 80 percent or more of the species in northern and central Europe, northern North America, Korea, and Japan are known. The known species are placed into about 110 families, only the most important of which are described below.

Order Araneida or Araneae (spiders)

More than 46,700 species described in about 110 families virtually worldwide. Arachnids with an unsegmented abdomen (opisthosoma) attached to cephalothorax (prosoma) by pedicel; prosoma with poison glands whose ducts open through large chelicerae with a movable fang, no pincers; leglike pedipalps usually with modifications (endites) on coxae to aid in feeding, modified as copulatory organs in males; abdomen usually with 2 pairs of respiratory organs, anterior book lungs and posterior tracheae; spinnerets at posterior end of abdomen; 4 pairs of walking legs; 1 or 2 pairs of coxal glands.

Suborder Labidognatha (araneomorph spiders)

Chelicerae labidognath (diaxial), attached below carapace; pedipalpal coxae with endites; usually 1 pair of book lungs, sometimes replaced by tracheae; heart with 3, sometimes 2, ostia; 13th through 18th ganglia lost, others fused.

Family Salticidae (jumping spiders)

More than 5,800 species; mostly tropical, but many species also found in northern and Arctic regions. Hunt during daylight hours by stalking and jumping on prey; best vision of all spiders.

Family Linyphiidae (sheet-web weavers and dwarf spiders)

4,300 species worldwide. Chelicerae with many teeth, often with stridulating (sound-producing) file on side; legs with many strong setae.

Family Araneidae (orb weavers)

2,800 species worldwide; *Araneus* widespread. Legs with strong setae; chelicerae strong, truncated proximally, with 6 to 8 teeth; usually construct orb webs; *Mastophora*, the bolas spider, probably venomous to humans; many species make no webs but instead wait for prey to stumble into them.

Family Lycosidae (wolf spiders)

2,300 species worldwide, including numerous species in the Arctic and on high mountains and the original tarantula, *Lycosa tarentula* of southern Europe. Eyes in 3 rows, anterior row with 4 eyes; hunting spiders;

females carry egg sac attached to spinnerets and carry young on abdomen; may dig tubes in soil.

Family Theridiidae (cobweb weavers or comb-footed spiders)

More than 2,200 species worldwide. Comb on each rear leg, used to throw silk over prey (attack wrap); chelicerae pointed on near end under carapace, few teeth; no stridulating structures on side of chelicerae; web irregular; sometimes hunt on ground; *Latrodectus* (widows) poisonous to mammals.

Family Thomisidae (crab spiders)

2,000 species; common and found worldwide. Often sit on flowers awaiting insects; some change colour; some live on or under bark.

Family Gnaphosidae

More than 2,000 common and widespread species. Anterior (lateral) spinnerets cylindrical and separated; posterior median eyes often oval and diagonal; nocturnal hunters.

Family Sparassidae or Heteropodidae (huntsman spiders, tarantulas in Australia)

Found in most tropical regions. Eyes in 2 rows; legs extended sideways; large, slightly flattened body.

Family Tetragnathidae (long-jawed orb weavers)

1,000 species worldwide. Males with long chelicerae; epigynum often secondarily lost.

Family Pholcidae (daddy longlegs spiders)

About 960 species worldwide. Similar to the nonspiders called daddy longlegs of the order Opiliones. Tarsi of legs with many false articulations; no tracheae; web loose and tangled; *Pholcus* of Europe and America.

Family Amaurobiidae

680 species common worldwide. Cribellum; 3 tarsal claws without brush of setae; tarsi with dorsal row of trichobothria; resemble Agelenidae; make an irregular funnel web between stones.

Family Dictynidae

About 560 species common in temperate areas. Cribellum; 3 tarsal claws; tarsi lack trichobothria and brush of setae; small in size; make irregular webs under leaves or in branches of herbs.

Family Clubionidae (sac spiders)

More than 530 species; common and widespread. Hunting spiders; anterior pair of spinnerets conical and touching; *Cheiracanthium* species somewhat venomous to humans.

Family Dysderidae

500 species worldwide. Respiratory tracheae with 4 spiracles (openings) in 2 pairs, 1 behind the other.

Family Agelenidae (funnel weavers)

500 species worldwide. Eyes in 2 rows; anterior (lateral) spinnerets long; most make a flat funnel web in vegetation and a tube-shaped retreat at the side; *Argyroneta*, the Eurasian water spider, in its own family but related to agelenids, constructs an air bell beneath the surface of slow-moving waters.

Family Ctenidae (wandering spiders)

440 mainly large tropical species. Eyes in 3 rows; median eyes face same direction, form a trapezoid wider behind than in front; eyes of posterior row largest, anterior laterals smallest; 1st 2 legs armed with strong ventral setae; some adults with only 2 tarsal claws; aggressive *Phoneutria fera* of South America venomous to humans.

Family Oxyopidae (lynx spiders)

420 species worldwide. Eyes arranged in a hexagon; hunt on vegetation, pounce on prey.

Family Uloboridae

About 260 species worldwide. Cribellum; lack poison glands; 3 tarsal claws; eyes in 3 rows; anal tubercle large; make orb webs; *Hyptiotes* are called triangle spiders.

Family Scytodidae (spitting spiders)

160 species mostly in tropical and subtropical regions. 6 eyes arranged in 3 groups; high, domed carapace, slopes anteriorly; catch prey with well-aimed squirt of saliva.

Family Sicariidae (six-eyed crab spiders)

About 130 species of Southern Hemisphere deserts; includes genus *Loxosceles* (recluse spiders). Large, 6 eyes, low carapace; legs extended toward sides; burrow in sand.

Family Theridiosomatidae (ray spiders)

More than 100 species. Globular abdomen; high clypeus (area below eyes); orb webs.

Family Deinopidae (ogre-faced spiders)

60 tropical species. Cribellum; 3 tarsal claws; eyes in 3 rows; anal tubercle large; *Dinopis* with 2 huge eyes, holds web, throws it over prey.

Suborder Orthognatha (mygalomorph spiders)

Most species large and long-lived in warm climates. 2 pairs of book lungs; heart with 4, rarely 3, ostia; bulb of male pedipalps simple; female without epigynum; 13th through 18th ganglia lost, others fused.

Family Theraphosidae (hairy mygalomorphs, tarantulas, baboon spiders)

900 mostly tropical species including tarantulas of North America, baboon spiders of South Africa, and bird-eating spiders of Australia, New Guinea, and South America. 2 tarsal claws; large, hairy, nonsocial, nocturnal; some burrow, others inhabit trees.

Family Dipluridae (diplurid funnel-web mygalomorphs)

188 mostly tropical species. 3 tarsal claws; 4 to 6 spinnerets, posterior (lateral) pair very long; body hairy; web similar to funnel webs of Agelenidae.

Family Ctenizidae (ctenizid trap-door spiders)

128 mostly tropical species. Chelicerae with structure (rake or rastellum) used to dig; 3 tarsal claws; eyes closely grouped; most species at least 3 cm or more in length; inhabit silk-lined tubes in ground, with

entrances covered by hinged silk lids.

Family Hexathelidae

85 mostly tropical species. Arched, glabrous carapace differentiates it from Dipluridae; funnel-web spiders (genus *Atrax*) of southeastern Australia are venomous.

Family Atypidae (purse-web spiders)

43 species of Europe, North America, Japan, Myanmar, and Java. 3 tarsal claws; 6 spinnerets; less than 3 cm long; live in closed silk tubes partly below ground; bite prey through tube and pull it in.

Suborder Mesothelae (segmented spiders)

About 100 species in 1 family, Liphistiidae, found from Japan to Southeast Asia. Inhabit trapdoor tubes in ground; remnants of abdominal segmentation clearly visible dorsally from 7th segment (pedicel) to 18th; 8 spinnerets at middle of abdomen; male pedipalps relatively complicated; epigynum absent in females; 18 ganglia in prosoma more distinctly separated than those in other suborders; heart with 5 pairs of ostia in segments 8 to 13; 2 pairs of book lungs.

Herbert W. Levi Lorna R. Levi Joseph Culin

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